

BS EN 16602-70-10:2015



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Space product assurance — Qualification of printed circuit boards

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National foreword

This British Standard is the UK implementation of EN 16602-70-10:2015.

The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

A list of organizations represented on this committee can be obtained on request to its secretary.

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circuits imprimés

Raumfahrtproduktsicherung - Qualifizierung von
Leiterplatten

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Foreword

This document (EN 16602-70-10:2015) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16602-70-10:2015) originates from ECSS-Q-ST-70-10C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2015, and conflicting national standards shall be withdrawn at the latest by July 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1

Scope

This Standard defines the requirements for evaluation, qualification and maintenance of qualification of PCB manufacturers for different types of PCBs.

This Standard is applicable to the following type of PCBs:

- Rigid PCBs (single-sided, double-sided, multilayer, sequential-laminated multilayer, metal core)
- Flexible PCB (single-sided and double-sided)
- Rigid-flex PCBs (multilayer and sequential-laminated multilayer)
- High frequency PCBs
- Special PCBs.

PCBs are used for the mounting of components in order to produce PCB assemblies performing complex electrical functions. The PCBs are subjected to thermal and mechanical shocks during their assembly such as mounting of components by soldering, rework and repair under normal terrestrial conditions, and in addition the complex PCB assembly are subjected to the environment imposed by launch and space flights.

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system — Glossary of terms
EN 16602-10-09	ECSS-Q-ST-10-09	Space product assurance — Nonconformance control system
EN 16602-20	ECSS-Q-ST-20	Space product assurance — Quality assurance
EN 16602-70	ECSS-Q-ST-70	Space product assurance — Material, mechanical parts and processes
EN 16602-70-02	ECSS-Q-ST-70-02	Space product assurance — Thermal vacuum outgassing test for the screening of space materials
EN 16602-70-08	ECSS-Q-ST-70-08	Space product assurance — Manual soldering of high-reliability electrical connections
EN 16602-70-11	ECSS-Q-ST-70-11	Space product assurance — Procurement of printed circuit boards
EN 16602-70-21	ECSS-Q-ST-70-21	Space product assurance — Flammability testing for the screening of space materials
EN 16602-70-22	ECSS-Q-ST-70-22	Space product assurance — Control of limited shelf-life materials
EN 16602-70-29	ECSS-Q-ST-70-29	Space product assurance — Determination of offgassing products from materials and assembled articles to be used in a manned space vehicle crew compartment
	IEC 60068-2-3 (1969-01)	Environmental testing. Part 2: Tests. Test Ca: Damp heat, steady state
	IEC 60068-2-14-am 1 (1986-01)	Environmental testing. Part 2: Tests. Test N: Change of temperature

	IEC 60068-2-20-am 2 (1987-01)	Environmental testing. Part 2: Tests. Test T: Soldering
	IEC 60249-1-am 4 (1993-05)	Base materials for printed circuits. Part 1: Test methods
	IEC 60326-2-am 1 (1992-06)	Printed boards. Part 2: Test methods
	IEC 60326-5-am 1 (1989-10)	Printed boards. Part 5: Specification for single and double sided printed boards with plated-through holes
	IEC 60326-8 (1981-01)	Printed boards. Part 8: Specification for single and double sided flexible printed boards with through connections
	IEC 60326-11 (1991-03)	Printed boards. Part 11: Specification for flex-rigid multilayer printed boards with through connections
	IEC 62326-4 (1996-12)	Printed boards. Part 4: Rigid multilayer printed boards with interlayer connections - Sectional specification
	IPC-4101	Specification for base materials for rigid and multilayer printed boards
	MIL-P-50884C	Printed wiring, flexible and rigid-flex

Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.

3.2 Terms specific to the present standard

3.2.1 associated test coupon

small piece of PCB designated to have a limited specific set of tests performed

NOTE The associated test coupon is manufactured as part of a PCB and at the final manufacturing stage it is separated from it. The associated test coupon is thus associated with the PCB, with which it was simultaneously manufactured.

3.2.2 blister

delamination in the form of a localized swelling and separation between any of the layers of a lamination base material, or between base material and conductive foil or protective coating

[IEC 60194 (1999-04)]

3.2.3 cover layer (flexible circuit)

layer of insulating material that is applied covering totally or partially over a conductive pattern on the outer surfaces of a PCB

[IEC 60194 (1999-04)]

3.2.4 crazing

internal condition that occurs in reinforced base material whereby glass fibres are separated from the resin at the weave intersections

NOTE 1 This condition manifests itself in the form of connected white spots or crosses that are below the surface of the base material. It is usually related to mechanically induced stress.

NOTE 2 See also “measling”.

[IEC 60194 (1999-04)]

3.2.5 delamination

separation between plies within a base material, between base material and a conductive foil, or any other planar separation with a PCB

NOTE See also “blister”.

[IEC 60194 (1999-04)]

3.2.6 dewetting

condition that results when molten solder coats a surface and then recedes to leave irregularly-shaped mounds of solder that are separated by areas that are covered with a thin film of solder and with the basis metal not exposed

[IEC 60194 (1999-04)]

3.2.7 flexible PCB

PCB either single, double sided or multilayer consisting of a printed circuit or printed wiring using flexible base materials only

[IEC 60194 (1999-04)]

3.2.8 haloing

mechanically-induced fracturing or delamination, on or below the surface of a base material, that is usually exhibited by a light area around holes or other machined features

[IEC 60194 (1999-04)]

3.2.9 high frequency PCB

PCB used for high frequency applications, that has specific requirements to the dielectric properties of the base laminates as well as special dimensional requirements to the lay-out for electrical purposes

3.2.10 inclusions

foreign particles, metallic or non-metallic, that may be entrapped in an insulating material, conductive layer, plating, base material or solder connection

[IEC 60194 (1999-04)]

3.2.11 key personnel

personnel with specialist knowledge responsible for defined production or product assurance areas

3.2.12 measling

condition that occurs in laminated base material in which internal glass fibres are separated from the resin at the weave intersection

NOTE 1 This condition manifests itself in the form of discrete white spots or “crosses” that are below the surface of the base material. It is usually related to thermally-induced stress.

NOTE 2 See also “crazing”.

[IEC 60194 (1999-04)]

3.2.13 metal core PCB

PCB using a metal core base material
[IEC 60194 (1999-04)]

3.2.14 multilayer PCB

PCB that consist of rigid or flexible insulation materials and three or more alternate printed wiring and/or printed circuit layers that have been bonded together and electrically interconnected
[IEC 60194 (1999-04)]

3.2.15 prepreg

sheet of material that has been impregnated with a resin and cured to an intermediate stage

NOTE B-staged resin.

[IEC 60194 (1999-04)]

3.2.16 printed circuit board (PCB)

printed board that provides both point-to-point connections and printed components in a predetermined arrangement on a common base

NOTE This includes single-sided, double sided and multilayer PCBs with rigid, flexible, and rigid-flex base materials.

[IEC 60194 (1999-04)]

3.2.17 rigid double-sided PCB

double-sided PCB, either printed circuit or printed wiring, using rigid base materials only
[IEC 60194 (1999-04)]

3.2.18 rigid-flex PCB

PCB with both rigid and flexible base materials
[IEC 60194 (1999-04)]

3.2.19 rigid-flex double-sided PCB

double-sided PCB, either printed circuit or printed wiring, using combinations of rigid and flexible base materials
[IEC 60194 (1999-04)]

3.2.20 rigid-flex multilayer PCB

multilayer PCB, either printed circuit or printed wiring, using combinations of rigid multilayer and flexible single and double-sided base materials

3.2.21 rigid PCB

PCB using rigid base materials only
[IEC 60194 (1999-04)]

3.2.22 rigid single-sided PCB

single-sided PCB, either printed circuit or printed wiring, using rigid base materials only

[IEC 60194 (1999-04)]

3.2.23 rigid multilayer PCB

multilayer PCB, either printed circuit or printed wiring, using rigid base materials only

[IEC 60194 (1999-04)]

3.2.24 scratch

narrow furrow or groove in a surface

NOTE It is usually shallow and caused by the marking or rasping of the surface with a pointed or sharp object.

[IEC 60194 (1999-04)]

3.2.25 sequentially laminated multilayer PCB

multilayer PCB that is formed by laminating together through hole plated double-sided or multilayer PCBs

NOTE Thus, some of its conductive layers are interconnected with blind or buried vias.

[IEC 60194 (1999-04)]

3.2.26 test pattern

part of the PCB that refers to the copper pattern on and within the PCB substrate for a specific test

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
CAD	computer aided design
CAM	computer aided manufacturing
M	major nonconformance
m	minor nonconformance
n.a.	not applicable
NRB	nonconformance review board
PCB	printed circuit board
PID	process identification document
PTH	plated-through hole

PTFE	polytetrafluoroethylene
r.m.s.	root-mean-square
TBD	to be defined

4

Principles

4.1 General

This Standard details the steps to obtain from the PCB manufacturer the qualification for supplying PCBs of an identified technology.

These steps are:

- a. Evaluation (see clause 5);
- b. Qualification (see clause 6):
 - Test and inspections (see clause 7),
 - Qualification approval (see clause 6.6);
- c. Maintenance of qualification (see clause 6.7).

4.2 Roles

For the need of this Standard the roles “PCB manufacturer”, “supplier”, “customer” and “qualification authority” have been explicitly introduced to allow proper allocation of requirements:

- a. The “PCB manufacturer” is the entity that manufactures the PCB.
- b. The “supplier” is the entity that uses the PCB for an instrument, for instance a subcontractor that delivers an electronics box. The supplier procures the PCB from the PCB manufacturer.
- c. The “customer” is the entity that uses the supplier’s product for a project, for instance a prime contractor that integrates an electronics box into a spacecraft payload. The role of supplier can coincide with the one of customer. The term customer does not refer to being the customer of the PCB manufacturer but refers to being the (prime) contractor of a space organisation initiating a space project.
- d. The “qualification authority” is the entity that reviews and accepts the qualification programme, evaluates the test results and grants the final approval. The role of customer can coincide with the one of qualification authority.

4.3 Specification of test requirements

Clause 7 describes the tests within the qualification programme in which the following three levels of requirement specifications are used:

- a. The requirement specifications that are generic for all types of PCBs are listed in clause 7.
- b. The requirement specifications that are specific to a particular type of PCB are listed in clause 9 and are referred to with the term “requirement” in clause 7.
- c. The requirement specifications that are determined by the supplier are referred to with the term “supplier’s specification” in clause 7.

5

Evaluation

5.1 General

- a. The PCB manufacturer who applies for the qualification of his PCB manufacturing line shall:
 - 1. request for an evaluation in conformance with clause 5.2;
 - 2. supply evaluation PCBs in conformance with clause 5.3;
 - 3. have a manufacturing line audit performed in conformance with clause 5.4.

NOTE If the result is satisfactory, the qualification authority can authorize the go-ahead of the qualification programme for each of the technologies that have been accepted.

- b. The PCB manufacturer and the qualification authority shall agree on the evaluation tests to be performed.

NOTE The evaluation tests can be an appropriate subset of the tests performed within the qualification programme.

5.2 Request for evaluation

- a. The PCB manufacturer's request for evaluation shall contain:
 - 1. a description of the technology for which the PCB manufacturer wishes to be evaluated;
 - 2. a description of the manufacturing line;
 - 3. past experience.
- b. Applications shall be signed by the person responsible for production and product assurance.
- c. Applications shall be addressed to the qualification authority.

5.3 Evaluation PCBs

- a. The PCB manufacturer shall produce three evaluation PCBs of each type with the materials, processes and equipment that are intended for use in subsequent production.

- b. The evaluation PCBs shall be representative in terms of technology for which the PCB manufacturer applies for qualification.

NOTE The term technology refers, among others, to:

- Dimensions of the boards, vias, pads and tracks
- Number of layers
- Pattern design.

- c. The evaluation PCBs shall represent the highest technological capability for which the PCB manufacturer applies for qualification.

- d. The PCB manufacturer shall perform the evaluation test and document it in conformance with Annex A.

NOTE The evaluation PCBs can be inspected at an independent certified test house.

- e. The evaluation PCBs shall be provided with associated test coupons.

5.4 Line audit

- a. Provided that the evaluation PCBs are accepted, the qualification authority shall audit the manufacturing line when PCB production is in progress.

- b. Before or during the audit, the PCB manufacturer shall make the following documents available to the customer:

1. Company organigram related to PCB production and control, including names and functions of all key personnel involved.
2. Identification of the parameters of the technologies that they wish to qualify.

NOTE See note in requirement 5.3b.

3. List of materials and equipment (including types and names of companies) used for production of PCBs.
4. List of process and control specifications with number, issue number, and date of issue.
5. Production flow-chart, including quality-assurance inspection point and relevant process specification.
6. Outline of test capabilities.

NOTE 1 Examples of test capabilities are metallographic examination, chemical analysis, failure analysis, mechanical and electrical test including functional testing of PCBs.

NOTE 2 These six documents can be gathered in a preliminary process identification document (PID).

6

Qualification

6.1 General

- a. A qualification programme shall be initiated in the following cases:
 - 1. Initial qualification.
 - 2. When previous qualification is more than two years ago and maintenance of qualification was not assured.
 - 3. Interruption of the manufacturing of the type of PCBs for more than two years.
 - 4. New technology.
 - 5. Change in the manufacturing line.
 - NOTE For example, any changes in material, chemical products, mechanical processing parameters, equipments.
 - 6. The manufacturing line was moved to another location.
 - 7. Changes in key personnel.

6.2 Qualification programme definition and approval

- a. After successful evaluation, the PCB manufacturer shall submit a qualification programme to the qualification authority for approval, after which the programme shall be initiated.
- b. The qualification programme shall identify:
 - 1. the key personnel involved;
 - 2. the test houses;
 - 3. the test procedure and test sequence;
 - 4. the proposed schedule of testing.
- c. Each test house shall have the approval of the qualification authority prior to commencement of the programme.
- d. The PCB manufacturer shall agree with the qualification authority on the monitoring during the qualification programme.

6.3 Nonconformance criteria

- a. The nonconformances shall be dispositioned in conformance with ECSS-Q-ST-10-09.
- b. Major nonconformances (M) shall be dispositioned at a nonconformance review board (NRB) established by the qualification authority and the PCB manufacturer.

NOTE This is because any major nonconformance (M) can result in the failure of qualification.

- c. Minor nonconformances (m) shall be:
 - 1. processed through an internal NRB of the PCB manufacturer to determine the causes and consequences;
 - 2. reported in the qualification test report in conformance with Annex B;
 - 3. assessed by the qualification authority;
- d. Nonconformance criteria ranked “m/M” shall be further classified by the PCB manufacturer, the supplier and the qualification authority.

6.4 Qualification programme implementation

- a. The qualification programme shall be performed by the PCB manufacturer or one or more independent test houses.
- b. The qualification programme shall be performed on six qualification PCBs.
- c. One additional qualification PCB shall be made for reference.
- d. The qualification programme shall be performed in conformance with the test sequence specified in Figure 6-1 and the test specification in Table 6-1 and explained in detailed in clause 7.
- e. A qualification test report shall be prepared in conformance with Annex B and submitted to the qualification authority for review and approval together with all prepared microsections.

NOTE The qualification authority can request the delivery of the inspected qualification PCBs.

- f. If the PCBs are used for manned space programmes the customer shall assure the PCB base material is tested for the following items:
 - 1. Flammability in conformance with ECSS-Q-ST-70-21.
 - 2. Offgassing (toxicity) and odour according to ECSS-Q-ST-70-29.

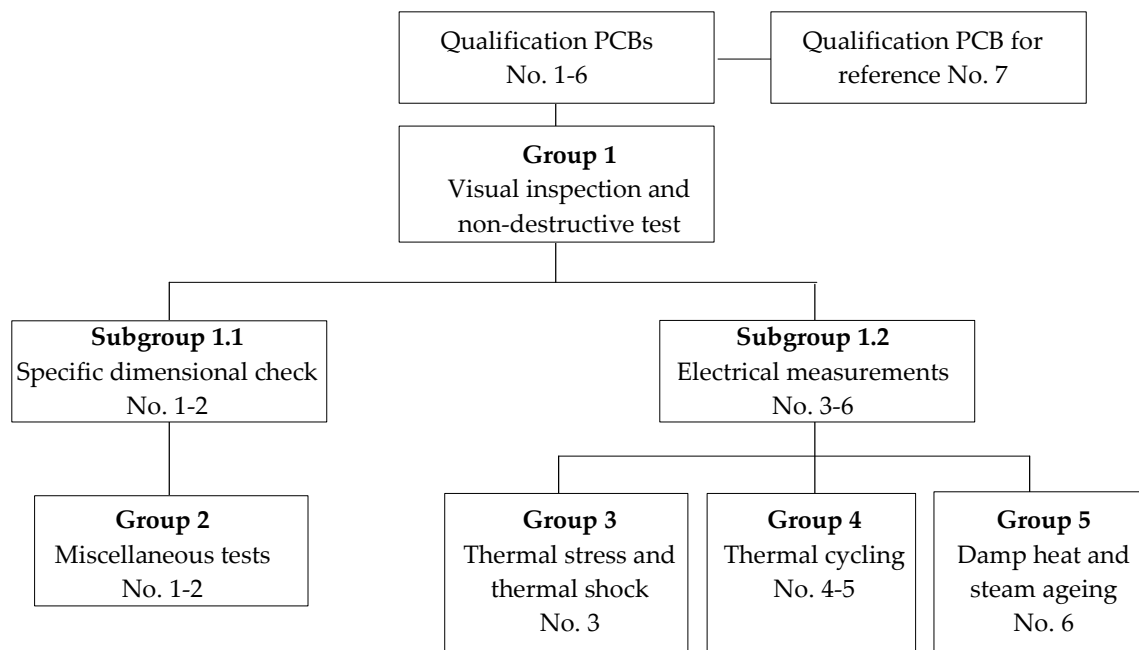


Figure 6-1: Test sequence

Table 6-1: Test specification
(Part 1 of 2)

Group	Tests	Clause	PCB no. Test pattern no.
Group 1	Visual inspection and non-destructive tests: - Verification of marking - Visual aspects - External dimensions - Warp - Twist	7.2 7.2.2 7.2.3 7.2.4 7.2.5 7.2.6	PCBs 1-6
Subgroup 1.1	Specific dimensional check	7.2.7	PCBs 1-2
Subgroup 1.2	Electrical measurements: - Intralayer ^a insulation resistance - Interlayer ^b insulation resistance - Dielectric withstanding voltage: • intralayer • interlayer - Continuity - Interconnection resistance - Impedance test - Dielectric constant and loss tangent for high frequency materials	7.2.8 7.2.8.2 7.2.8.3 7.2.8.4 7.2.8.5 7.2.8.6 7.2.8.7 7.2.8.8	PCBs 3-6 Test pattern A Test pattern H Test pattern A Test pattern H Test pattern D Test pattern E Test pattern Y Test pattern W
Group 2	Miscellaneous tests	7.3	PCBs 1-2
Subgroup 2.1	Solderability test: - Wettability - Microsectioning (option)	7.3.2 7.3.2 7.3.4.3	Test pattern J Test pattern J
Subgroup 2.2	Mechanical tests: - Peel strength - Pull-off strength - Flexural fatigue (only for double sided flexible PCB) - Bending test (only for rigid-flex)	7.3.3 7.3.3.1 7.3.3.2 7.3.3.3 7.3.3.4	Test pattern B Test pattern B Test pattern X
Subgroup 2.3	Coating tests: - Coating adhesion of non-fused SnPb finishes - Analysis of SnPb coating - Microsectioning	7.3.4 7.3.4.1 7.3.4.2 7.3.4.3	Test pattern G Test pattern G Test pattern F
Subgroup 2.4	Electrical tests: - Current overload: • Short-time overload • Long-time overload - Internal short circuit	7.3.5 7.3.5.1 7.3.5.1.2 7.3.5.1.3 7.3.5.2	Test pattern E Test pattern C
Subgroup 2.5	Physical tests: - Water absorption - Outgassing	7.3.6 7.3.6.1 7.3.6.2	Test pattern K

Table 6-1: Test specification
(Part 2 of 2)

Group 3	Thermal stress	7.4	PCB 3
	Solder bath float and vapour phase reflow simulation	7.4.2	PCB (without test pattern F)
	- Substrate aspect test	7.2.3	PCB
	- Peel strength	7.3.3.1	Test pattern B
	- Continuity	7.2.8.5	Test pattern D
	- Interconnection resistance	7.2.8.6	Test pattern E
	- Microsectioning	7.3.4.3	Test pattern J
	Rework simulation (thermal shock, hand soldering)	7.4.3	Test pattern F
Group 4	- Microsectioning	7.3.4.3	Test pattern F
	Thermal cycling	7.5	PCBs 4-5
	- Substrate aspect test	7.2.3	PCBs
	- Peel strength	7.3.3.1	Test pattern B
	- Continuity	7.2.8.5	Test pattern D
	- Interconnection resistance	7.2.8.6	Test pattern E
	- Intralayer ^a insulation resistance	7.2.8.2	Test pattern A
	- Interlayer ^b insulation resistance	7.2.8.3	Test pattern H
Group 5	- Dielectric withstanding voltage:	7.2.8.4	
	• intralayer		Test pattern A
	• interlayer		Test pattern H
	- Microsectioning	7.3.4.3	Test pattern F
	Damp heat — Steam ageing	7.6	PCB 6
	Damp heat	7.6.2	PCB (without test pattern F)
	- Peel strength	7.3.3.1	Test pattern B
	- Intralayer ^a insulation resistance	7.2.8.2	Test pattern A
	- Interlayer ^b insulation resistance	7.2.8.3	Test pattern H
	- Dielectric withstanding voltage:	7.2.8.4	
	• intralayer		Test pattern A
	• interlayer		Test pattern H
	- Microsectioning (if required)	7.3.4.3	Test pattern F
	Steam ageing	7.6.3	Test pattern F
	- Solderability test:		
	• Wettability	7.3.2	Test pattern F
	- Microsectioning (if required)	7.3.4.3	Test pattern F
^{a.} i.e.: in the same layer. ^{b.} i.e.: between opposite layers.			

6.5 Qualification PCBs

6.5.1 General

- a. The qualification PCBs shall have test patterns that enable evaluation of the specific characteristics, summarised in Table 6-1 and described in detail in clause 7.
- b. The qualification PCB shall represent the highest technological capability for which the PCB manufacturer applies for qualification.
- c. The qualification PCB shall consist of a test pattern demonstrating the technological capability (test pattern L) together with the other test patterns.

NOTE The pattern drawing on layer 1 of the individual test patterns given below and shown as an example in Figure 6-2 can be used.

- d. The PCB manufacturer and the qualification authority shall agree on the layout of the capability pattern.

NOTE The capability pattern can be an actual PCB circuit to be used in the space project.

- e. The test pattern layout and design shall be in conformance with the referenced IEC specification if applicable:
 - 1. Single and double sided PCBs with plated-through holes: IEC 60326-5.
 - 2. Rigid multilayer PCBs with interlayer connections: IEC 62326-4.
 - 3. Single and double sided flexible PCBs with through connections: IEC 60326-8.
 - 4. Flex-rigid multilayer PCBs with through connections: IEC 60326-11.
- f. The test pattern layout and design for sequentially laminated multilayer PCBs and special PCBs shall be agreed between PCB manufacturer, supplier and qualification authority.

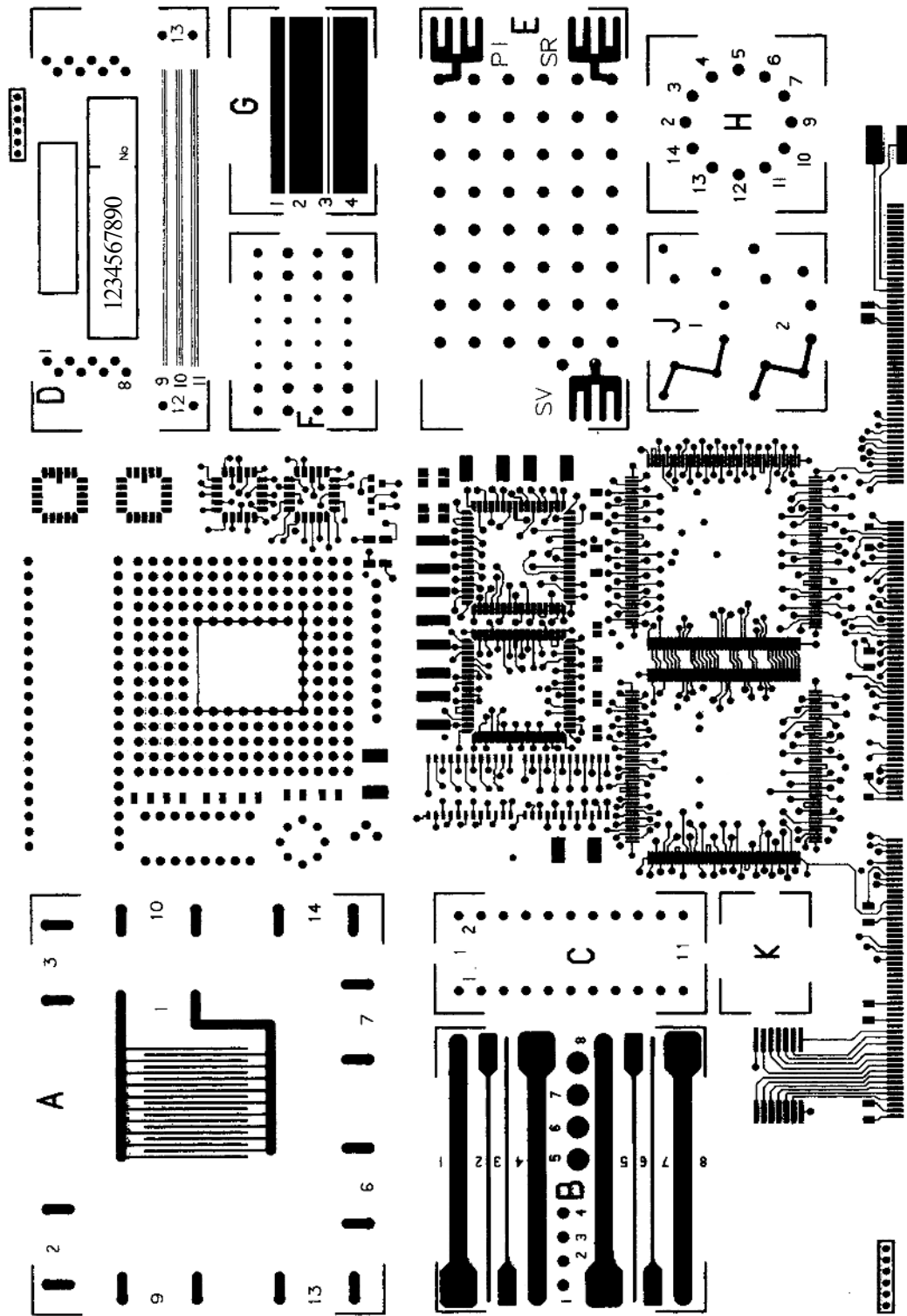


Figure 6-2: Example of a qualification PCB layout with patterns for testing and a pattern for demonstration of the technological capability

6.5.2 Test pattern A: Electrical test

- a. The following measurements shall be performed on test pattern A:

1. Intralayer insulation resistance.
2. Dielectric withstanding voltage.

NOTE See example in Figure 6-3.

- b. The conductor width and spacing within each layer shall represent the minimum dimensions to be qualified.

NOTE The comb pattern can provide a useful tool for evaluating cleanliness.

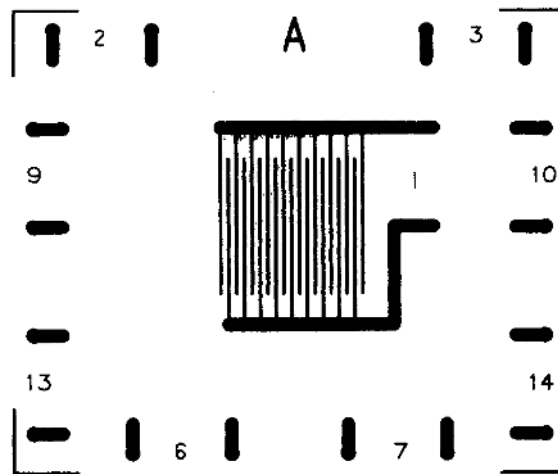


Figure 6-3: Example of test pattern for intralayer insulation resistance and dielectric withstanding voltage testing

6.5.3 Test pattern B: Mechanical test

- a. The following measurements shall be performed on test pattern B:

1. Peel strength of copper track on laminate.
2. Pull-off strength of surface mount pads.
3. Surface solderability.

NOTE See example in Figure 6-4.